LIMITED

WRK/MKG/INF/L.119
2 January 1964

ORIGINAL : FRENCH

UNITED NATIONS

ECONOMIC COMMISSION FOR ASIA AND THE FAR EAST

Committee for Coordination of Investigations
of the Lower Mekong Basin
(Cambodia, Laos, Thailand and Vietnam)

REPORT ON THE OPERATION OF A BARRAGE ON THE TONLE SAP

by

M. SCHMID
Chief of the Botanical Mission

REPORT ON THE OPERATION OF A BARRAGE ON THE TONLE SAP

Possible implications for the vegetation on the edges of the Tonle Sap of the construction of a dam providing for the regulating of the streamflow of the Lower Mekong

(M. Schmid)

Upon the suggestion of Mr. d'Aubenton, coordinator of the studies on the biology of the fish on which Cambodian fisheries are dependent, I had been asked by the Mekong Committee to study the vegetation under periodical flooding conditions in the vicinity of the Tonle Sap in an attempt to determine the possible implications of the construction of a dam to strengthen the moderating influence of the Great Lake on the Lower Mekong floods on the distribution of the main vegetation groups and, consequently, on the associated fish-life.

In two notes prepared after visits made from 18 May to 2 June 1961 and 12 to 30 November 1962, I had reported on my observations about the connexion between the current distribution of vegetation groups and the variations in the ecological conditions, factors such as the physical conditions, the duration of the flooding periods, the movements of the water, the importance of the silting process... being considered by me as paramount importance.

The knowledge I may have of the behaviour of the most common species is obviously too incomplete for me to perceive always with sufficient clearness the way in which those species would react if the environment to which they are adapted were to be suddenly modified. Furthermore, topographic and sedimentation data available to me are not sufficient to enable me to assess with certainty the changes which, as a result of the operation of the dam, would appear in the different biotopes.

/Nevertheless,

Nevertheless, taking into account the information gathered as well as the most plausible assumptions and these reservations being made, it seems I might to some purpose examine the probable implications on the structure and composition of vegetation of a modification of the hydraulic regime and indicate which pattern of operation would in my opinion be least likely to involve disturbances which might be harmful to fish-life.

Two separate questions arise:

1) What changes will occur in the vegetation following the construction of the barrage? Can the extent of these changes vary with the conditions of utilization of the barrage, it being understood that these conditions are largely determined by the initial purpose of the project, i.e. the control of the Mekong floods?

2) Assuming that the operation of the barrage results in a change of the distribution of the main vegetation groups, coupled with a marked reduction of the areas occupied by some of them, will the fish life be seriously affected by this factor?

Providing the elements of an answer to the first of these questions is the very reason of the survey I was asked to conduct. The second question pertaining to animal biology rather than botany, I shall do no more than submit a few comments on this subject.

I - Implications

I - Implications for the vegetation of the operation of the barrage

From the statement made in Phnom Penh in May 1961, during an experts' meeting, it appears that the operation of the barrage should include 3 main stages: in Spring, the closing of the gates would prevent the first flood water from passing from the Mekong into the Great Lake. A little later, the gates being opened, the Summer floods, whose volume is much greater, could be absorbed by the depression of the Tonle Sap all the better as the water levels, across the dam - a difference which would have gradually increased during the first stage - would be greater. Lastly, during the ultimate phase, the dam would have a controlling and slowing down effect on the receding flow.

At the end of the receding stages, the water of the Lake would be kept at a level 1.50 m higher than the low water level under natural conditions, because of the beneficial effects of such a scheme on fish life. Conversely, the operation of the barrage would entail a slight lowering of the maximum level reached by the water, this lowering being to some extent compensated, as regards vegetation on the edge of the flooded zone, by an extension of the duration of the high water period.

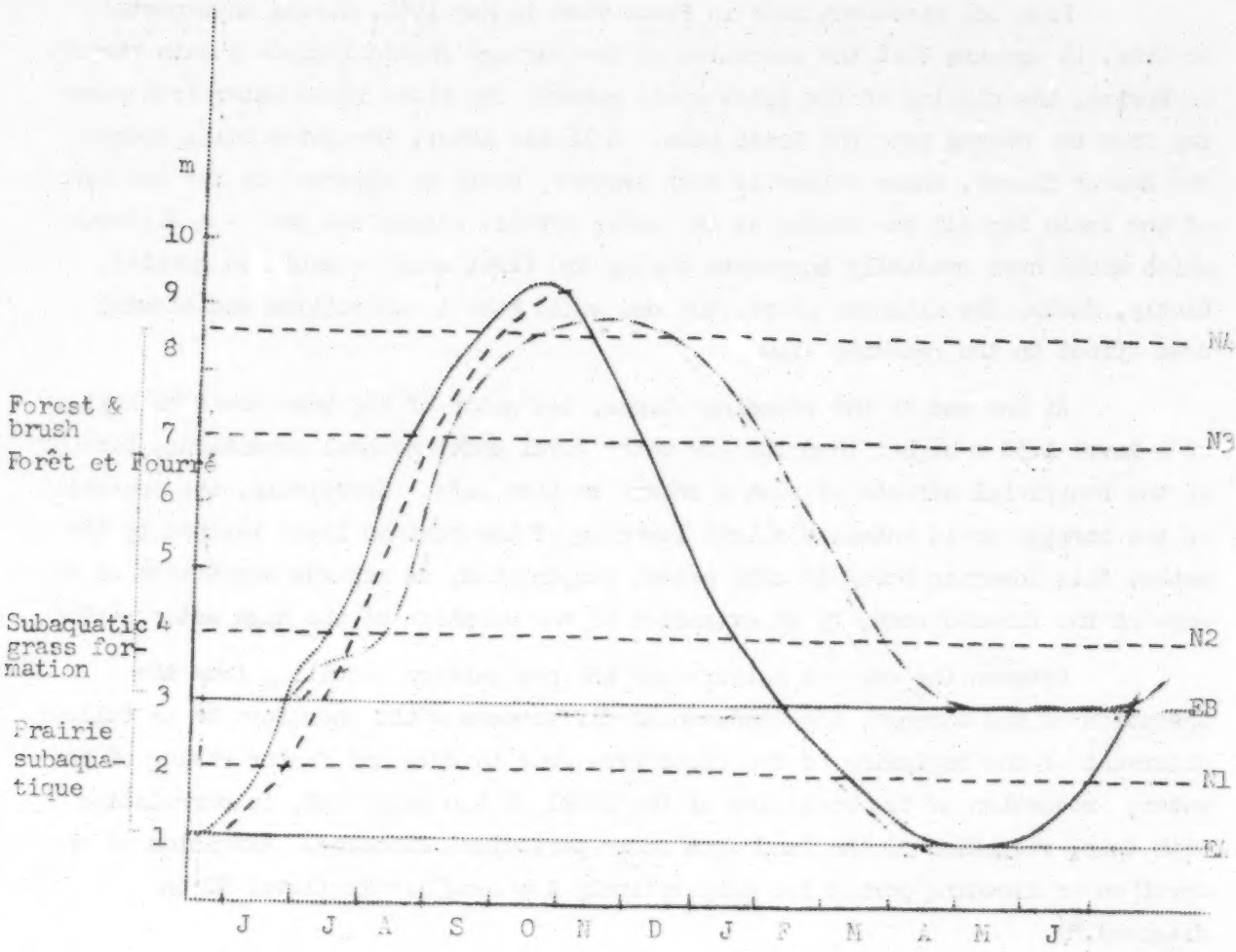
Between the current pattern and the new pattern resulting from the operation of the barrage, the fundamental differences would therefore be as follows: deferment of the beginning of the flood from June to July and faster rising of the water; reduction of the variation of the level of the water and, in correlation with this, reduction of the land area under periodical flooding. Extension of the duration of flooding period for comparatively low land levels (level N2 on diagram).1/

/The main characteristics

1/ Through the extension of the ebb period, soft water pressure in the lower delta would longer remain sufficient to prevent the intrusions of brackish or acid water. However, the slowing down of the emptying process of the water of the Lake might have some unfavourable effects in connexion with the sedimentation and slow down the evacuation of the polluted water which tends to accumulate in some poorly drained areas.

Variations of the water level of the Great Lake during the year (in the vicinity of Snoc Trou)

Variations de niveau des eaux du Grand Lac au cours de l'année (au voisinage de Snoc-Trou)



——— Régime 1962 Regime 1962

- - - Régime 1963 Regime 1963

..... Régime prévu (d'après l'exposé sommaire du plan indien et compte tenu des recommandations de M. d'AUBENTON)

Anticipated regime (from the outline contained in the Indian plan and taking into account Mr. d'Aubenton's recommendations)

E_A - Niveau d'étiage actuel. Present low water level

E_B - Niveau prévu. Anticipated water level

The main characteristics of the vegetation may now be recalled:

The flora is rather original but seems comparatively poor. This originality and this lack of variety show that the conditions to which the species are preadapted are very special.

The structure and the composition of the vegetation vary according to the regime of floods. Some groups are aquatic, some are semi-aquatic, others are amphibious, the latter, which constitute what is called the flooded forest, playing in connexion with physionomy by far the most important part.

Among the varieties included in the different groups, some appear to be linked to environment conditions only fulfilled in very localised areas; some others, either by reason of their more adaptable nature or because the conditions they require are less closely connected with local factors, are much more widely distributed; different kinds characteristic of the flooded forest (Barringtonia, Diospyros, Coccoceras...), different shrubs and lianas belong to this second group. Excepting perhaps a few aquatic plants, the species included in the flora of the Tonle Sap could not live in stagnant water.[1/] Their development cycles appear to be conditioned to a greater extent by the pattern of floods than by the climate: the stolons of the subaquatic graminaceae extend as the water rises; their inflorescences appear at the moment when the flood reaches its maximum level; most of the ligneous species, on the other hand, flower when their stems are no longer covered by the water.[2/] The height at which trees ramify varies with the level reached by the water during the flood period, the lowest branches generally being in the vicinity of this level. The trees retain their leaves all the year round; the shrubs which are entirely covered by the flood grow a new foliage when the water has receded. The standing grass, perennial or annual, which grows on the low lands or on some alluvial banks, have a very short development cycle and disappear in the early stages of the flood. Among the subaquatic stoloniferous plants, some become assimilated to the standing grass, during the low

/water stages,

1/ The ligneous varieties do not have pneumatophores.

2/ The flowering induced by the high and dry period may appear shortly after the return of the water, especially for trees, which react much less rapidly than shrubs.

water stages, while some others disappear; one should however not be led to the conclusion that the high and dry period is not necessary for the completion of their cycle.

In the light of these factors, the following observations may be made:

The operation of the dam may deeply disturb plant life on the lowest lands levels (levels N1 and N2): on the one hand the extension of the area permanently covered by water will result in the withdrawal of the flooded forest and the subaquatic grass formation; on the other hand, the extension of the duration of the flood period on lands periodically above water level will result in the disappearance of some varieties. It may also be feared that the rising of the low water level should make more difficult the evacuation of the water bearing organic matter, and more or less acid, which has a tendency to stagnate in the flooded forest. The speeding up of the rising of the water at the beginning of the flood period may indeed hamper the development of subaquatic stoloniferous varieties as well as of some shrubs (Sesbania) whose rate of growth is sufficient, under natural conditions, to keep them from being submerged.

It is true that the stoloniferous graminaceae of the Tonle Sap are also found in the regions where floods are much more sudden. As regards trees, whose crest spreads above the level of the highest water, and the shrubs, which are completely submerged during the flood period, it does not seem that this speeding up of the rise of the water could be very harmful. The deferment of the low water period from February-June to April-July does not seem of a nature to hurt many varieties, as the reproduction cycles seem to have more connection with the rise and fall pattern of the water than with the climate. It would be more harmful to late flowering species (influence of the summer rains); practically without influence upon herbaceous vegetation (Spring and Autumn flowering). But it is very important that the duration of the high and dry period should not be reduced and even at comparatively low levels (level N2), its extension would even be desirable to offset the consequences of the raising of the water level during the low water period.

/Resuming

Resuming discussion of these data, let us see how the operation of the dam might affect the extension of each one of the groups described in our studies on vegetation.

1) Groups on the Lake's edge

(The area occupied by these groups is not extensive; they might however, considering their location, have a great importance for fish life).

Echinochloa stagnina grass formation.

This semi-aquatic graminaea, with long stolons floating during the flood period, occupies sometimes well ahead of the forest's edge incompletely consolidated alluvial banks slightly above low water level. An elevation of the water level during the low water stages should therefore result at least temporarily in a significant reduction of its extension. It may be that after a few years the raising of the present alluvial banks or the constitution of new banks will promote its reappearance.

There should also be a regression of Sesbania paludosa which is found in the same sites as Echinochloa but further away from the Lake, along the banks of the great preks.

Sphenoclaea, Aeschynomene, Leersia grass formation ...

This group is seen in the same areas as the Echinochloa, but its period of active life coincides with the low water season. It should disappear as long as the alluvial beds barely emerging in the low water stages and which constitute its preferential ground have not been reconstituted (delta of Snoc-Trou).

Ficus heterophylla brush ...

This formation, mostly seen along alluvial banks emerging well above low water level and in process of consolidation, could be fairly easily reconstituted as a transfer to the higher reaches of its current home generally seems to be possible. It thus would penetrate into the Sorghum zones which are now cultivated during the low water period (Snoc-Trou delta).

/2) The "flooded forest"

2) The "flooded forest"

This formation includes trees whose trunks, and sometimes for a short period the lowest branches, are submerged in flood periods, as well as an undergrowth of shrubs and lianas which completely disappears during the high water stages. As a result of the destruction of the forest by man, there develops a brush that is difficult to penetrate. It is likely that the undergrowth or brush elements play the greatest part in connexion with fish life.

Both forest and substitution brush grow on already consolidated alluvia. These are amphibious formations, as most of their constituting elements seem to be able to thrive on lands with fairly different flooding patterns. It may however be observed that the composition of vegetation varies as one gets closer to the limits of the flooding zone; it also varies as one moves away from the edges of the Lake or the banks of the preks (less mobile and less aerated water). It does not look as if these variations as such could be of great significance in relation to fish life.

It thus seems that the operation of the dam would not induce spectacular changes in the vegetation, as far as the "flooded forest" is concerned. The fringes would fall some way back, at distances varying with topographical conditions; but the implications of this withdrawal, in the light of the importance of all areas occupied, cannot be very serious for fish life as few species, according to Mr. d'Aubenton, enter very deeply into the clumps. In many sectors, this withdrawal would anyway not be immediate, some marginal species appearing to be able to live on for several years on permanently submerged land. There also would be a process of vegetation transfer, the varieties which currently are most abundant on the edge of the Lake tending to replace on the intermediate levels between N2 and N3 (see diagram) varieties more susceptible to prolonged immersion. On the fringes of the flooded zone, no significant changes would be noted.

3) Herbaceous

3) Herbaceous aquatic or subaquatic groups of the bongs

Floating or submerged aquatic grass formations.

Their development should be promoted by the raising of the low water level and the slowing down of the evacuation of water when flood water recedes. The increase in the superficy of current permanent or temporary ponds will have in this respect less significance than the creation of new pools of still water, for aquatic grass formations, perhaps because of their susceptibility to the action of the winds on the water, cannot wholly occupy water expanses above a given size.

Subaquatic grass formations.

(Mostly Graminaceae: Sacciolepis...)

Vegetation in these formations is constituted by stoloniferous kinds with ecological requirements similar to those of Echinochloa stagnina but whose development is interfered with by the agitation of the water and which, on the other hand, do well in comparatively acid and poorly aerated water. They can be seen in spots inside the forest, particularly in the west (sector of Prek Préas Dam and in the north of the small Lake); they grow extensively on the limits of the flood zone where peripheral water collects in troughs, which drup up later and less completely than "flooded forest" lands.

As the operation of the dam would slow down the evacuation of the water from these troughs, it might promote at the expense of Graminaceae the extension of the aquatic grass formation area. But it is chiefly for grass formations located inside the forest that a reduction of the oxygen content of the water and the resulting pollution might be feared. The grass formations on the edge of the flood area being probably at a comparatively high level, it on the contrary is the improvement of the draining conditions resulting from a lowering of the maximum flood level which could lead to their regression.

/4) Subaquatic groups

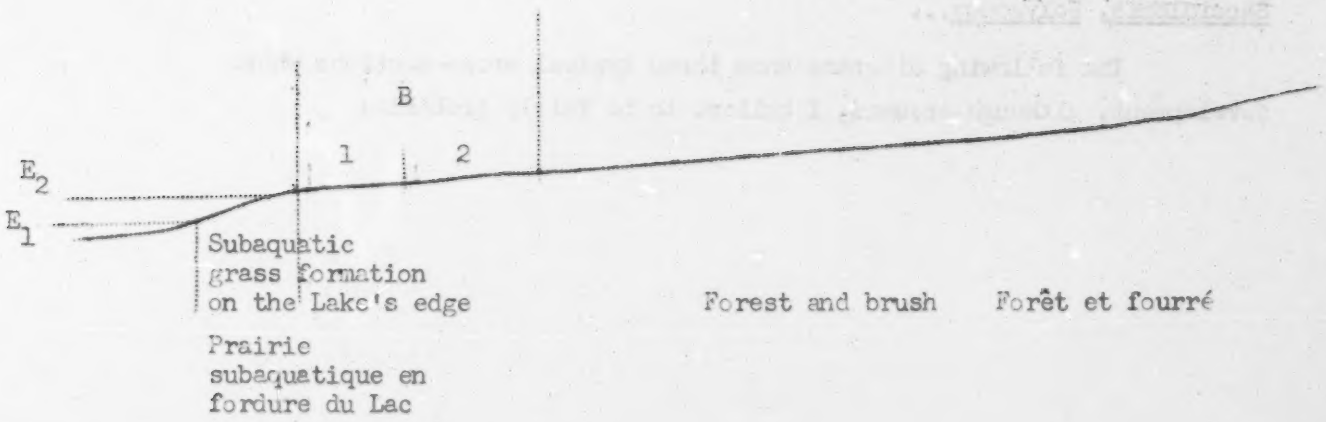
4) Subaquatic groups of the banks

The raising of the low water level should induce a slight displacement of the Polygonum and Achyranthes groups, commonly seen along the preks, without bringing about any significant alterations of their currently occupied area.

In the foregoing remarks, I did not take into account the possible variations from one sector to another of topographical conditions, which may result in either an increase or a reduction of the areas in which the consequences of the operation of the dam would be most clearly felt.

A study conducted by SOGREAH experts, who agreed to let us have some of their results, showed that the extension of the superficy of the flooded zone does not follow a regular pattern in relation to the rising of the water. In the early stages of the flood, the horizontal advance of the water is comparatively slow by comparison with their vertical movement; when the level of the Lake has reached level 3, the horizontal progressive becomes faster, the expanding of the flooded area for a given rise of the water level between levels 4, 5 and 7 being almost three times as great. It later slows down, while remaining in the vicinity of level 9 more rapid than in the vicinity of the low water level.

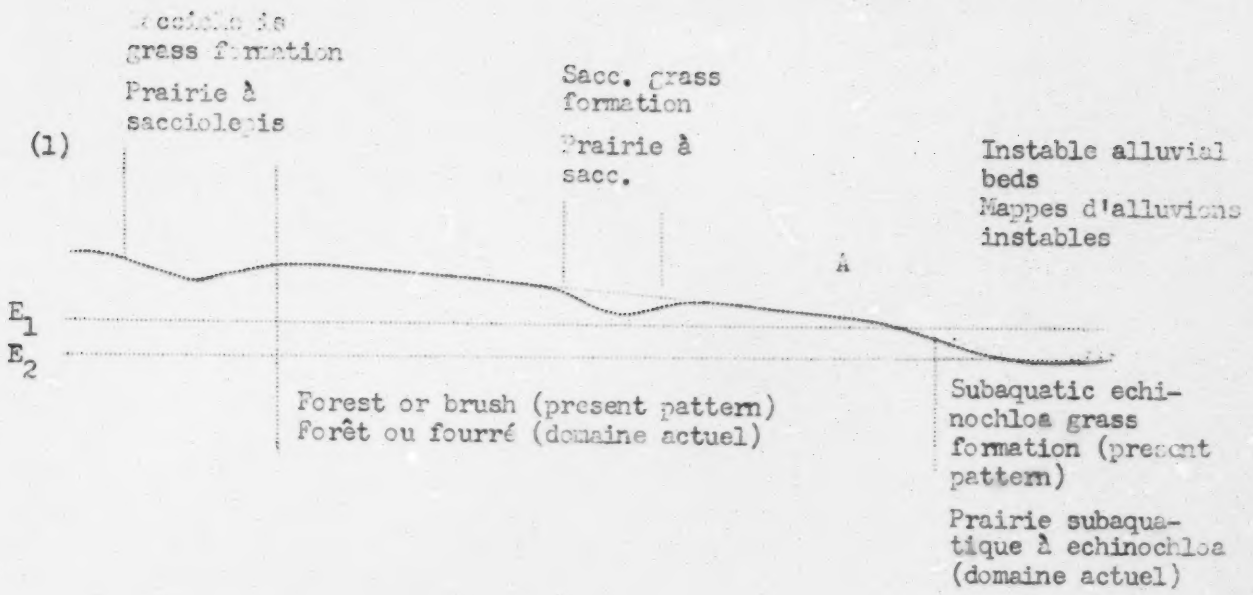
The average topographical cross-section of the edge of the Lake near the limits of the trough would therefore be approximately as follows:


B
1
2
E_2
E_1
Subaquatic grass formation on the Lakc's edge
Prairie subaquatique en fordure du Lac
Forest and brush
Forêt et fourré

On this diagram, it is clear that the raising of the low water level from E1 to E2 would result in the displacement of the subaquatic grass formation (Echinochloa...) from A to B. Actually, its new sector would probably be limited to zone B2. The ligneous groups superficy would diminish from 20 to 30%. After a new equilibrium had set in, vegetation changes would chiefly consist, at least in the forest sector, in the falling back of such species as are ill-adapted to prolonged submersion, those which currently are most abundant in sectors located on the edge of the Lake and most interesting in connexion with fish life being helped by an extension of the duration of the flooding period on the limit of the area covered by the waters.

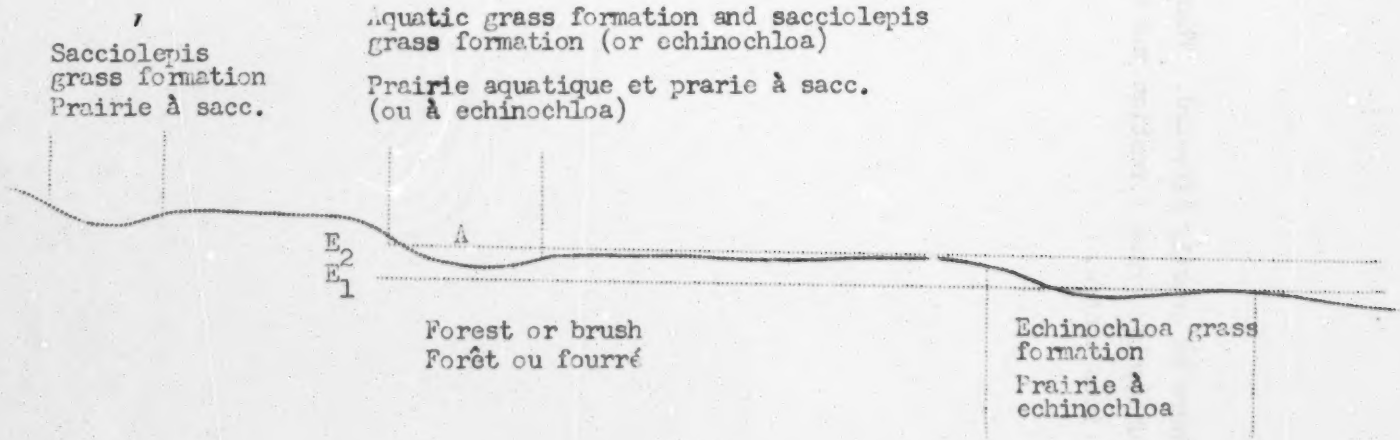
These very general data do not consider local topographical variations which, while they influence the distribution of the above mentioned groups, are determining for the existence of aquatic and subaquatic grass formations with Sacciolepis, Polygonum...

The following diagrams show three typical cross-sections whose development, although assumed, I believe to be fairly probable:


Saccio.le
grass formation
Prairie à
sacciolepis
(1)
Sacc. grass
formation
Prairie à
sacc.
Instable alluvial
beds
Mappes d'alluvions
instables
A
E_1
E_2
Forest or brush (present pattern)
Forêt ou fourré (domaine actuel)
Subaquatic echi-
nochloa grass
formation (present
pattern)
Prairie subaqua-
tique à echinochloa
(domaine actuel)

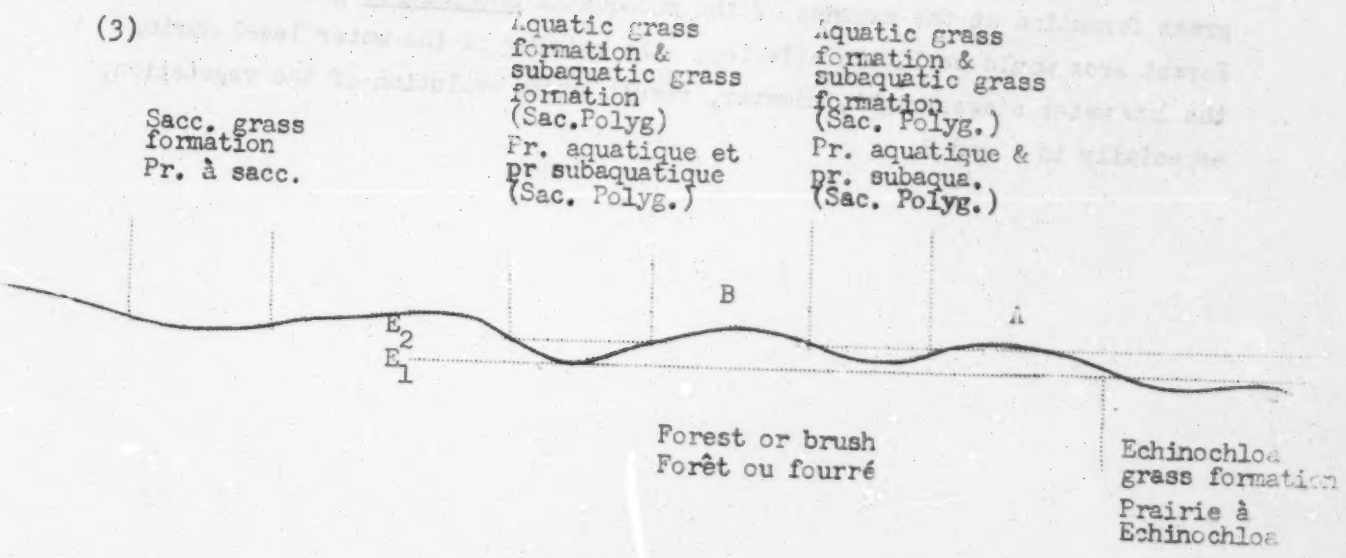
The raising of the low water level from E1 to E2 will more or less affect the forest area according to the angle and length of the slope in A. The Sacciolepis grass formation will not be much affected.

(2)


Sacciolepis
grass formation
Prairie à sacc.
Aquatic grass formation and sacciolepis
grass formation (or echinochloa)
Prairie aquatique et prarie à sacc.
(ou à echinochloa)
A
E2
E1
Forest or brush
Forêt ou fourré
Echinochloa grass
formation
Prairie à
echinochloa

The forest area would here be greatly affected. There probably would be a regression of the subaquatic grass formation and a transfer of Echinochloa grass formation into zone A.

(3)


Sacc. grass formation
Pr. à sacc.
Aquatic grass formation & subaquatic grass formation (Sac.Polyg)
Pr. aquatique et pr subaquatique (Sac. Polyg.)
Aquatic grass formation & subaquatic grass formation (Sac. Polyg.)
Pr. aquatique & pr. subaqua. (Sac. Polyg.)
B
A
E2
E1
Forest or brush
Forêt ou fourré
Echinochloa grass formation
Prairie à Echinochloa

Probable extension, after the barrage had started operation, of the aquatic grass formation at the expense of the subaquatic Sacciolepis grassland. Forest area would be little affected; the raising of the water level during the low water stages might, however, result in an evolution of the vegetation, especially in A and B.

II - Implications for fish life

It is understood that vegetation largely conditions the living of the fish of the Great Lake; however, one knows nothing about the part played by specific varieties or vegetation groupes.

The ligneous varieties can only indirectly contribute to the feeding of the fish; tree leaves remain permanently above water level and shrub leaves are not renewed until the beginning of the period of emersion. The part played by the subaquatic grass formation does not seem either to be very important (tough grained stolons, at least in the case of the Graminaceae, stems bearing leaves and flowers sticking out of the water); the part played by the aquatic grass formation, especially in case of submerged groups (Ceratophyllum group) is undoubtedly not negligible, but remains secondary. On the other hand, the decaying of huge masses of loose vegetable débris, either when the water rises (leaves of the brush and undergrowth), or during the low water stages (case of the subaquatic grass formation), makes possible the development of an abundant plancton.

The commissioning of the dam, by reducing the yearly amplitude of the water level variation, might cause a reduction in the quantities of organic matter available to the plancton in the development of which autotrophic organisms would therefore play a more important part, a result which in itself is of little consequence.

One should however not forget to consider the possible changes in the quality of the water penetrating into the Great Lake: the content of this water in some specific elements still largely conditions plant life and, to an even larger unit, the development of the plancton, as the decaying process of organic matter as well as the multiplication of autotrophic organisms are basically dependent on this.

Analysis made in 1962 by the Institut Paster upon the request of Mr. d'AUBENTON have shown a sharp reduction in the Ca^{++} content of the water of the Tonle Sap in Phnom Penh, at the beginning of the flood period.(1)

/ We thus

(1) The amount of dissolved mineral substances is in the water of the Tonle Sap very similar to that of the water of the Mekong throughout the flood period; it is much lower during the ebb period and during most of the low water stages.

We thus see that the Ca^{++} content falls from 20.8 mg.l in May (15 May) to 10.4 in June (15 June); it increases later to settle in the vicinity of 15 in July-August, and 18 in September. It falls when the water has reached its maximum level and remains around 9 during the ebb and low water periods, their sharp rise in May indicating the first stages of the penetration of the water of the Mekong, slightly ahead of the flood. Although the Mg^{++}, Na^{+} and K^{+} content does not show similar variations, this fall ofthe content in Ca^{++} in June goes together with a sharp reduction of the overall alcalinity.

One might feel inclined to conclude that, as the closing of the dam at the beginning of the flood period prevents the penetration of the comparatively demineralized waters, its impact on the fish life in the Great Lake can only be beneficial.

Mr. d'AUBENTON recommends to leave the dam open in the first stages of the flood because of the importance of fish migrations at that time; but there is no certainty that in Snoc Trou the arrival of the fish coincides with that of the water with a low Ca^{++} content.

CONCLUSIONS

The commissioning of a dam for controlling the Lower Mekong floods will necessarily bring some changes in the composition and the distribution of the plant groups occupying the depression of the Tonle Sap.

These changes will be felt all the more as the raising of the low water level will be more significant.

They will be conditioned by the extension of the submersion period, by the raising of the water level during the emersion period, and, lastly, to a lesser extent, by the difference in the average percentages of useful substances between the water which now flows from the Mekong into the Lake and the water which the dam will let pass into it.

If, according to the recommendations of the Chief of the Ichthyological Mission, the new low water level upstream of the dam reaches an elevation of 3 metres, it may be assumed that the current superficy of the flooded forest would be reduced by 20 to 30 %. The area occupied by the subaquatic grass formation on the edges of the Lake, the area occupied by the groups of the preks and bengs, undergo appreciable changes, but these changes would result in displacements rather than a regression. Ultimately, once the transformations required for the adaptation to new environment conditions had been made - transformations which, in the case of the forest, could extend over several tens of years and which, in the case of the herbaceous vegetation, in priciple fairly rapid, could also be of long duration owing to the intervention of sedimentation processes, it does not seem as if they could at more or less long term result in an impoverishment of fish life.

The commissioning of the dam will, however, mark the beginning of a crisis period. With a view to lessening the impact, the raising of the low water level should be effected only gradually. It is essential that the period between the end of the ebb period and the reopening of the dam should extend over 2 months at least, a period of 3 months being preferable. It also is important that the rise

/ of the water

of the water following upon the opening of the dam should not be too rapid. A 1 month to 6 weeks postponement of the low water period, from the beginning of April to March, should not have very unfavorable consequences. An extension of the maximum water level period would be beneficial to the development on the bor[illegible] of the flooded zone of the varieties now abundant in the sectors most assiduously visited by the fish. The evolution of the vegetation in the areas occupied by the Sacciolepis grass formation, because of the lack of sufficiently detailed topographic data, is difficult to foretell whatever the pattern advocated for the operation of the dam, however, assuming that these advantages of the commissioning of the dam be clearly felt in the locations occupied by groups of this type, it should be possible at least in some cases to counteract the ill-effects through comparatively inexpensive local measures.